



Arsenic in Urine

April 23, 2010

After reviewing urine sample results, discussing fish consumption, and researching the potential for health effects from acute and chronic exposure to arsenic in fish tissue for a Fulton county resident, it was determined that it is unlikely that the levels of inorganic arsenic in his urine samples indicate exposures of concern that might result in long-term health effects. Because of the amount of fish and shellfish he consumes, there is no additional suspected exposure pathway for inorganic arsenic. However, it would be a wise health choice for him to reduce his consumption levels by following risk-based consumption guidelines.

There is no federal or state consumption guidance for arsenic in fish and shellfish, because most arsenic in fish is in the organic form. Species-specific fish consumption guidelines are available for polychlorinated biphenyls, (PCBs), toxaphene, mercury, and dioxins to help reduce the levels of these chemicals, and arsenic, that you are exposed to. The most effective ways to ensure that you are not at risk for exposure to elevated levels of arsenic in fish is to eat a variety of fish and shellfish, limit consumption of top predator and bottom feeder species, and to be sure the source of the products you consume are safe.

Arsenic Exposure

Within a few days following exposure, ingested arsenic is rapidly excreted from the body into the urine. To evaluate exposure, arsenic is measured in urine, hair, fingernails, or blood. Measurement of arsenic in blood is not a reliable indicator of chronic exposure to low levels of arsenic—it is cleared from the blood within a few hours and reflects only very recent exposure. Blood arsenic levels also are difficult to interpret because the relationship between levels of exposure and blood concentrations has not been well established. Hair and fingernail analyses may provide an indication of exposures that occurred up to several months prior to testing, but both can absorb and strongly retain arsenic from external sources in addition to consumption. Testing the levels of arsenic in urine is the most reliable method for measuring arsenic exposure, particularly exposures occurring within a few days of the specimen collection. Fluctuations in urine excretion rates make a

24-hour collection an optimal sample. Ease of collection, however, has resulted in most exposure studies using a first-morning void or a random sample. In fact, the first-morning void urine results have correlated well with 24-hour results. Urine is tested for total arsenic (which could come from all sources—food, water, air, soil, and dust), for inorganic arsenic (which might be coming from contaminated soil and dust), or for both. Total urinary arsenic is mostly organic arsenic from food sources, which is much less toxic than inorganic arsenic. Speciated urinary arsenic is preferable to total urinary arsenic because the speciated forms can distinguish between exposure to inorganic arsenic and its metabolites and the relatively nontoxic forms of organic arsenic commonly found in seafood.

In the United States, dietary intake of total arsenic on average is approximately 58 ug/day. Of that, up to 10 ug/day may be inorganic arsenic. Consistent with several studies, total arsenic concentrations were highest in the seafood sampled (ranging from 160 nanograms per gram (ng/g) in freshwater fish tissue to 2,360 ng/g in marine fish). A nanogram is one-billionth of a gram. In contrast, average inorganic arsenic in seafood ranged from <1 to 2 ng/g.

Average muscle tissue concentrations of arsenic in rays were about 16 micrograms per gram (ug/g) of tissue. Assuming that average arsenic concentrations are similar in shark tissue, an 8 oz. portion of shark would have approximately 3,600 ug or 3.6 milligrams (mg) of arsenic. A 4 oz. portion would contain approximately 1.8 mg of arsenic. Therefore, each time a 70 kilogram (kg) man would consume an 8 oz. serving of shark, he would be exposed to approximately 0.05 mg/kg of body weight each time such a serving was consumed.

Assuming that shark is not consumed every day, but rather twice per week, a chronic (> one year) exposure dose to arsenic would be approximately 0.014 mg/kg/day for an 8 oz. portion. (If that portion is 4 oz. instead, the chronic exposure dose would be 0.007 mg/kg/day). The doses calculated for exposure to individual chemicals are then compared to an established health guideline, such as an ATSDR minimal



CHEMICAL HAZARDS PROGRAM
Environmental Health Branch
Georgia Department of Community Health
Atlanta, GA



risk level (MRL) or an EPA reference dose (RFD), in order to assess whether adverse health effects from exposure are expected.

Sample Results

The Fulton county resident's urine arsenic results showed a concentration of 511 ug/L total arsenic and 32 ug/L of inorganic arsenic. Inorganic arsenic levels represent 6.3% of the total arsenic level detected in your urine. The general consensus in the literature is that about 85 – 90% of the arsenic in the edible parts of marine fish and shellfish is organic arsenic and approximately 10% is inorganic arsenic.

In order to determine a relative exposure dose to arsenic based on his diet, we can use some conservative assumptions. Assuming he eats marine fish four times per week, and the fish he consumes contains 2,360 ng/g of total arsenic, an 8-ounce serving of fish would contain 6.6 mg arsenic. A 4-ounce serving would contain 3.3 mg arsenic. Because inorganic arsenic comprised 6.3% of the total arsenic found in his urine, an 8-ounce serving of marine fish would contain 0.41 mg inorganic arsenic. A 4-ounce serving would contain 0.02 mg inorganic arsenic. Therefore, using the above assumptions, his exposure dose to inorganic arsenic would be approximately 0.0034 milligrams per kilogram of body weight (assuming you weigh 70 kg) per day (mg/kg/day) if he ate an 8-ounce serving of marine fish four times per week. If he ate a 4-ounce serving of marine fish per week, his exposure dose to inorganic arsenic would be approximately 0.0017 mg/kg/day.

To assess whether he might be at risk to adverse health effects from the consumption of marine fish using the above assumptions, the doses calculated for exposure to individual chemicals are then compared to an established Health Guideline, such as an MRL, in order to assess whether adverse health impacts from exposure are expected. Health Guidelines are chemical-specific values that are based on available scientific literature and are considered protective of human health. Human data was used to develop the MRL for arsenic from a study in Taiwan where a significant dose-response relationship was found between arsenic levels in artesian well water in 42 villages in the southwestern Taiwan. Residents in these villages have used water high in arsenic for more than 70 years.

In the Taiwanese study, the no observed adverse health effects level (NOAEL) exposure dose observed from the study population was 0.0008 mg/kg/day, where hyperpigmentation and keratosis was the effect being sought. The lowest observed adverse health effects level (LOAEL) exposure dose observed from the study population was 0.014 mg/kg/day, where increased incidences of dermal lesions were observed. To account for human variability, an uncertainty factor of three was used to establish the MRL. ATSDR's MRL for exposure to inorganic arsenic was established at 0.0003 mg/kg/day.

Therefore, using the calculated exposure dose to inorganic arsenic based on our assumptions, if the Fulton county resident ate an 8-ounce serving of marine fish four times per week, his exposure dose would be 11 times higher than the MRL, which is considered a safe level, and 4 times lower than the NOAEL, where no adverse health effects were observed in the Taiwanese study. If he ate a 4-ounce serving of marine fish four times per week, his exposure dose would be 6-times higher than the MRL, which is considered a safe level, and 8-times lower than the NOAEL.

The American Conference of Industrial Hygienists maintains guidance values for assessing the level of contaminants in workers who are potentially exposed in occupational settings. For the monitoring of worker's urinary inorganic arsenic levels, concentrations up to 35 µg/L are considered acceptable. This level is below the point at which adverse health effects are expected in a worker population. In addition, normal concentrations of arsenic in human urine can range from 5-40 ug/day. However, arsenic in urine was found to be correlated with age. The older you are, the higher the arsenic concentration excreted in your urine. In general, the arsenic content in the human body is approximately 3-mg and tends to increase with age.